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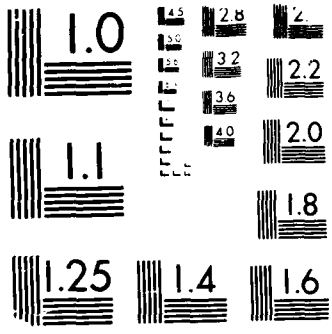

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Study for the Determination of General and Specific Properties of Wide Energy-Band Gap HgCdTe in the 1 to 2 Micrometer Wavelength Range.

Principal Investigator: T. Nguyen-Duy

Contractor: Societe Anonyme de Telecommunications

Contract Number: DAJA45-87-C-0020

2nd Interim Report: October 1987 - December 1987

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SUMMARY.

The second phase of this contract was dedicated to the optimization of the technical fabrication parameters of HgCdTe avalanche photodiodes in the 1.3 µm to 1.55 µm wavelength region.

In addition, the electroluminescent properties and the technical feasibility of HgCdTe emitters were investigated.

FABRICATION OF HgCdTe AVALANCHE PHOTODIODES.

Technology.

The fabrication technology implemented for the deliverable avalanche photodiodes under this contract is **planar.** The following fabrication steps are observed:

- Surface preparation (THM-grown, p-type, base material);
- Formation of a guard ring;
- Formation of the photo-sensitive zone by implantation, followed by annealing;
- Passivation;
- Formation of the n-contacts;
- Formation of the p-contact on the back face;

- Dicing of the chips;

- Installation in special housings suitable for subsequent measurements.

Diode Tests.

Following installation in the special housings, the following characteristics are determined (a complete measurement report will accompany each diode):

- I-V characteristics;

- Current reliability (test at 100 μA over 10 s);

- Current magnitude at the -10 V, -20 V, -40 V bias points, at the avalanche point (V_B) and at 0.9 V_B;

- Forward diode resistance;

- Junction capacitance as a function of bias voltage;

- Quantum efficiency for M (Multiplication coefficient) = 1;

- Spectral response;

- Multiplication coefficient as a function of bias voltage;

- Electrical bandwidth

EVALUATION OF LARGE AREA PHOTODIODES.

The possibility of fabricating sensitive areas as large as 2 cm x 2 cm has been considered. SAT has no experience with sensitive areas in excess of 5 mm diameter. The behavior of larger areas can be determined through extrapolation which we tried to justify.

A photodiode is a current generator. The total current (I_{sat}) is the sum of the following contributing currents:

I_{ϕ} : photon flux current

I_{diff}: diffusion current

I_{g-r}: generation-recombination current

I_{tunnel}: tunneling current (negligible for this composition)

I_{leak}: leakage current, caused by surface leaks and by leaks around the junction, a direct function of the technological process

$$I_{sat} = I_{\phi} + I_{diff} + I_{g-r} + I_{tunnel} + I_{leak}$$

The contributing currents I_{diff}, I_{g-r}, I_{tunnel}, can be expressed as a function of the diode sensitive area. They can also be expressed through the intrinsic concentration (n_i) as a function of the semiconductor electrical parameters and how they are affected by the fabrication technology.

ELECTROLUMINESCENT PROPERTIES

Radiative and Auger lifetimes as a function of composition and carrier concentration were investigated. The prevailing process corresponding to the 1 - 2 μm wavelength region is the radiative process, except at 1.5 μm where the spin-orbit coupling energy favors the Auger recombination.

CONCLUSION

Diodes with sensitive areas 0.080 mm, 0.250 mm, 1 mm, 2 mm and 5 mm diameter were fabricated at both the 1.3 μm and 1.55 μm wavelengths.

Examination of saturation currents derived from the I-V characteristics as a function of sensitive area for these diodes enabled us to predict, through extrapolation, the saturation currents that one might expect from devices with much larger sensitive areas. This extrapolation is predicated, of course, on comparable electrical characteristics, on similar materials and on an identical planar process.

The magnitude of the saturation currents for diodes of such large sensitive areas may turn out to become a limiting factor.

FUTURE PLANS

Our next effort will be directed to the following:

- Measurement of the deliverable photodiodes;
- A study to determine the effect of the operating temperature;
- An investigation of the recombination mechanisms as a function of carrier concentration.

Appendix to Second Interim Report (Contract DAJA45-87-C-0020)

Unused funds at the end of this report period: $ 67,000

No important property was acquired with contract funds during the period covered by this report.

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